Further Integrating IHDs into the DSM Customer Offering

Behavior, Energy and Climate Change Conference
Sacramento, California
October 20, 2015

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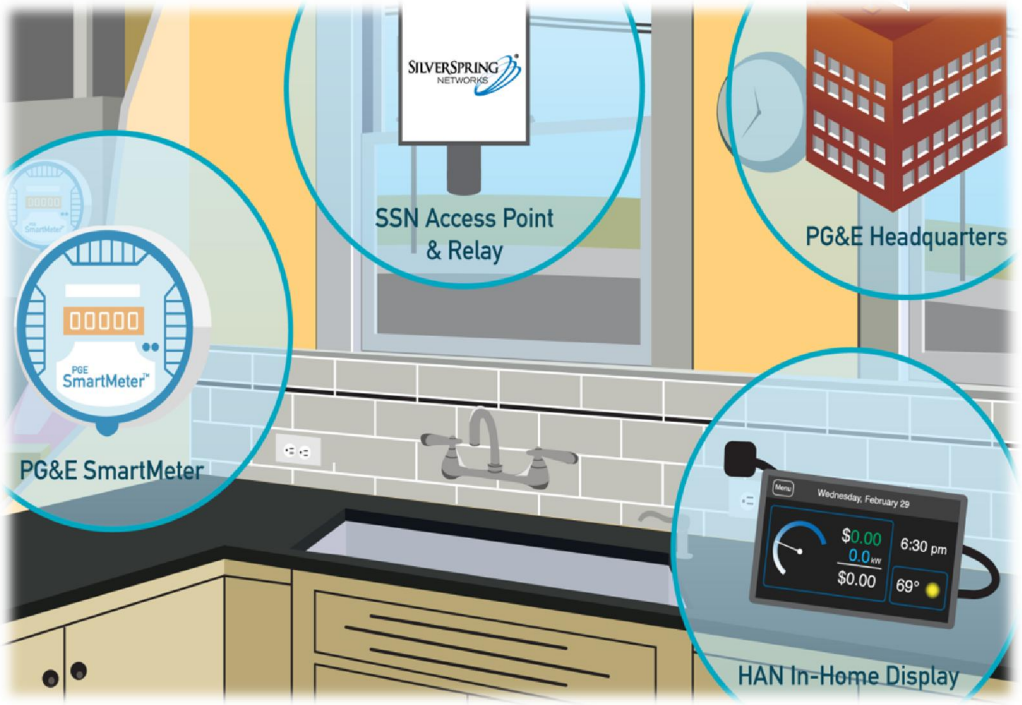
Agenda

- **Background on IHDs and HAN at PG&E**
- **PG&E HAN Phase 3 Pilot**
- **Evaluation Methodology**
- **Energy Savings and Demand Response Load Impacts**
- **Conclusions**

Wherefore the IHD?

- **A central demand-side problem in the pre-AMI world is that electricity users are like drivers at the gas station that can't see how much gas they're pumping and don't even know the price per gallon!**
- **In-home displays (IHDs) let customers see energy usage, demand, and electric rates instantaneously**
- **IHDs are Home Area Network (HAN) devices that can leverage AMI systems to offer greater control over usage and bills**



Utility experience with IHDs is growing

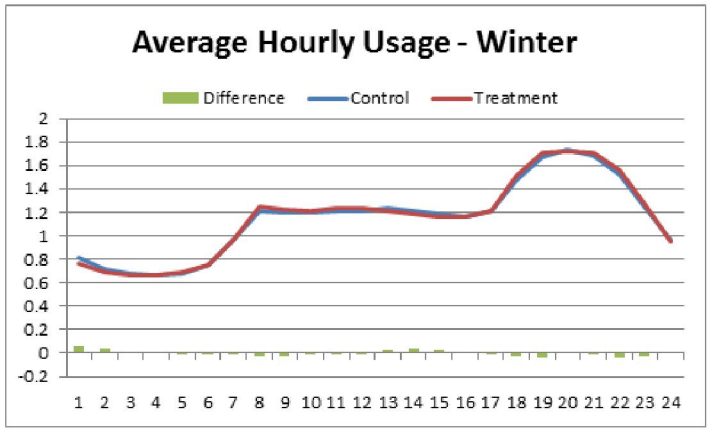
- **As early as 2011, a number of jurisdictions have adopted HAN implementation policies.**
  - The *peaksaver*PLUS direct load control program in Ontario, Canada includes an IHD component
  - CPUC issued decision 11-07-056 directing the three California electric IOUs to adopt HAN implementation plans
- **Fast forward to 2015, we now have few years of experience with HAN technologies**
- **Nexant has worked in both jurisdictions to estimate energy savings attributable to IHDs**
- **We have not been able to find IHD energy savings in Ontario but the experience in California has been more interesting…**

PG&E's HAN Phase 1 pilot

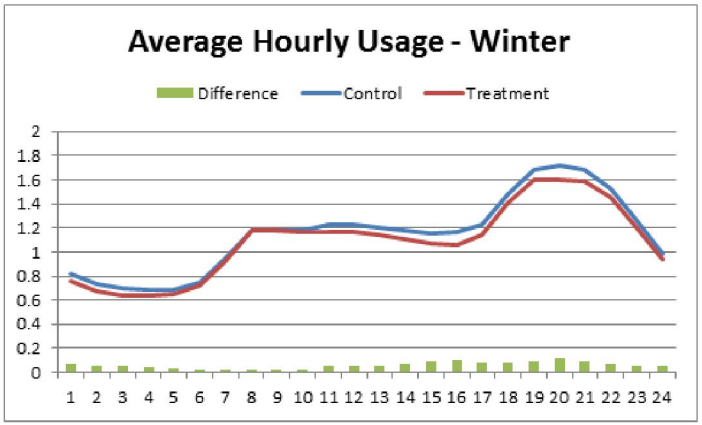
- **Tested one type of tabletop device**
- **Zigbee communication with the PG&E SmartMeter™**
- **Displays real-time electric usage, electric rate, and cost**
- **IHDs were installed in 350 homes of customers on the standard residential tiered rate**
- **PG&E supported the devices for the 2012-2013 heating season**

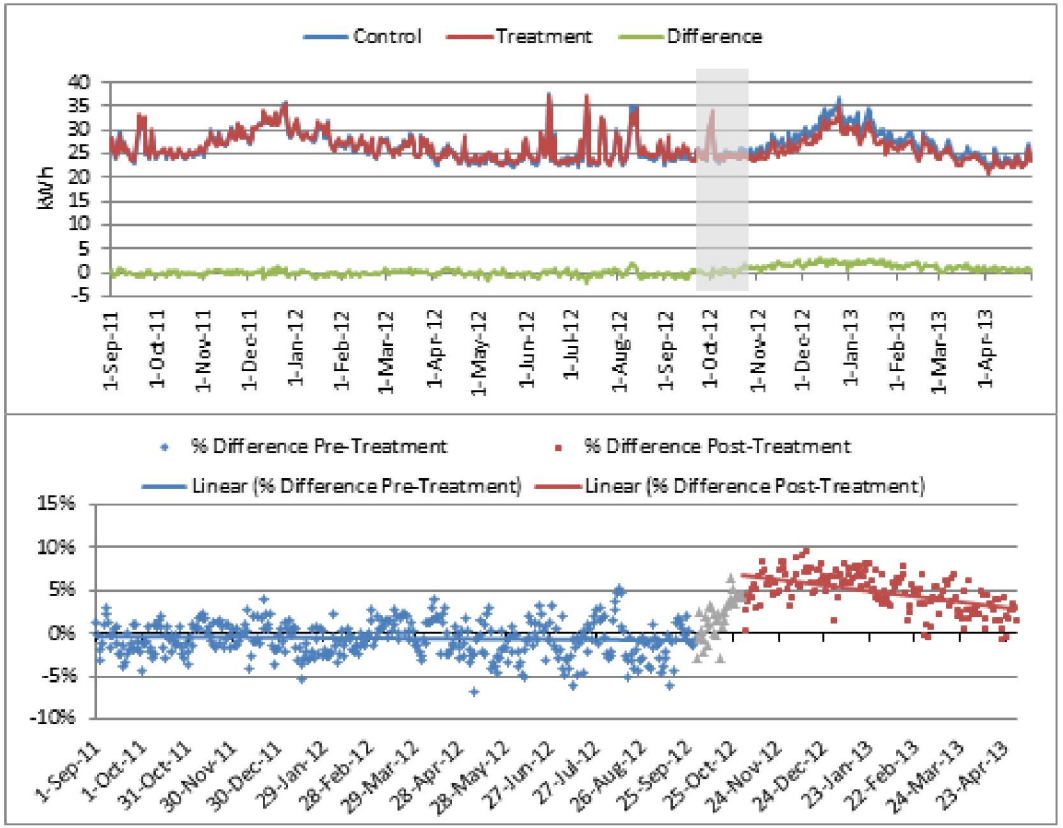
Energy savings for the HAN Phase 1 pilot were a big surprise

Pretreatment



Posttreatment





Measure	Average Daily Impact	Standard Error	95% CI	
			Lower	Upper
kWh	-1.55	0.34	-0.88	-2.22
Percent	-5.6%	1.2%	-3.2%	-8.0%

HAN Phase 3 pilot launched summer 2014

- **Designed to test new backoffice capabilities to provide more customer value:**
  - Self service device registration online on the PG&E customer portal
  - Presentment for TOU rates in addition to standard tiered rates
  - Presentment of dynamic SmartRate™ (overlay onto TOU or tiered rates)
  - Notification of SmartDays™

- **SmartRate customers were originally the targeted test group, recruitment opened up to non-SmartRate TOU customers as well**

HAN Phase 3 tested two IHD platforms that use Zigbee communications

- **Tabletop unit and gateway (serving website and app)**
  - Both devices display TOU information (for those on TOU) and SmartDay notification (if enrolled in SmartRate)

Phase 3 pilot participants were recruited from across the service territory

- **A total of 1,685 residential customers participated**

Electric Rate	Number of Customers
SmartRate	1,073
E-6 TOU	278
EV-TOU	274

IHD Type	Number of Customers
Tabletop	841
Gateway	844

What's the best way to measure energy savings from IHDs?

- **The best way to determine whether or not the IHDs tested in this pilot led to changes in electricity use is through an experimental, rather than observational approach**
- **Observational, or within-subjects, studies are challenged because changes in weather, economic conditions, or household behavior (all unrelated to the treatment) can cause changes in electricity usage over time**
- **Comparing usage of participants to non-participants can lead to selection bias**

If possible, conduct an RCT or RED study

- **The gold standard of experimental design is a randomized control trial RCT or a randomized encouragement design**
- **But both methods can be difficult to implement for technology pilots:**
- **RCTs require either a recruit and deny or recruit and delay strategy which can have customer satisfaction repercussions**
- **True RCTs are impossible to implement anyways because the technology may not be installed (either it gets left in the box or doesn't work when installed)**
- **RED studies do not deny access to the treatment, but the necessary sample sizes to detect small changes in energy usage (1-2%) can be orders of magnitude larger than for an RCT, depending on the acceptance/installation rate**

This evaluation took a quasi-experimental approach

- **A matched control group was selected using propensity score matching:**
  - Estimate a probit model that calculates the probability of a customer participating in the treatment group, using information like electricity usage patterns and geographic location to build the model
  - Pairs of customers (participants and non-participants) are selected that have the most similar estimated probabilities of participation
- **Control groups were selected separately for EV-TOU, E-6 TOU, and SmartRate customers**
- **Control groups were also selected separately for estimating peak period demand and energy consumption**

Analysis was conducted with hourly interval data

- **Interval data for participants and matched control group was used to create panel datasets for hourly usage and monthly usage**
- **Panel regressions with customer-consistent and time-consistent fixed effects were used to estimate:**
  - Hourly on-peak load impacts for E-6 TOU customers
  - Hourly on-peak load impacts for EV-TOU customers
  - Hourly on-peak load impacts for SmartRate customers on SmartDays
  - Monthly energy savings for E-6 TOU customers
  - Monthly energy savings for EV-TOU customers
  - Monthly energy savings for SmartRate customers

Hourly load impacts

Smart Rate (n > 1,000)

Hour Ending	HAN Customer Load	Ref. Load	Imp.	Imp.	Impact 90% Confidence Interval	
	(kW)	(kW)	(kW)	(%)	Lower	Upper
15	0.56	0.59	0.03	5%	0.00	0.06
16	0.58	0.61	0.03	4%	-0.01	0.07
17	0.63	0.67	0.04	7%	0.00	0.08
18	0.69	0.71	0.02	3%	-0.02	0.06
19	0.77	0.77	0.00	0%	-0.04	0.03
Average	**0.65**	**0.67**	**0.02**	**3%**	**-0.01**	**0.05**

E-6 TOU (n< 300)

Hour Ending	HAN Customer Load	Ref. Load	Imp.	Imp.	Impact 90% Confidence Interval	
	(kW)	(kW)	(kW)	(%)	Lower	Upper
14	0.59	0.59	0.00	-1%	-0.03	0.02
15	0.59	0.58	0.00	-1%	-0.03	0.02
16	0.61	0.62	0.01	1%	-0.02	0.03
17	0.65	0.67	0.01	2%	-0.01	0.04
18	0.72	0.73	0.01	2%	-0.02	0.04
19	0.82	0.84	0.03	3%	-0.01	0.06
Average	**0.66**	**0.67**	**0.01**	**1%**	**-0.01**	**0.03**

EV-TOU (n< 300)

Hour Ending	HAN Customer Load	Ref. Load	Imp.	Imp.	Impact 90% Confidence Interval	
	(kW)	(kW)	(kW)	(%)	Lower	Upper
13	0.97	1.01	0.04	4%	0	0.09
14	0.99	1.02	0.04	4%	-0.01	0.08
15	0.98	1	0.02	2%	-0.02	0.07
16	1.04	1.07	0.02	2%	-0.03	0.08
17	1.12	1.18	0.05	5%	0	0.11
18	1.24	1.32	0.08	6%	0.01	0.14
19	1.34	1.46	0.12	8%	0.05	0.18
20	1.45	1.54	0.09	6%	0.02	0.15
21	1.55	1.63	0.08	5%	0.02	0.14
Average	**1.19**	**1.25**	**0.06**	**5%**	**0.02**	**0.10**

Monthly Energy Savings

Smart Rate (n > 1,000)

Month	HAN Consumption	Reference Consumption	Impact	Impact	Impact 90% Confidence Interval	
	(kWh)	(kWh)	(kWh)	(%)	Lower	Upper
Aug.	536	538	2	0.4%	-5	10
Sep.	511	510	-1	-0.2%	-9	7
Oct.	502	513	11	2.2%	1	22
Avg.	**513**	**517**	**4**	**0.8%**	**-2**	**10**

E-6 TOU (n< 300)

Month	HAN Consumption	Reference Consumption	Impact	Impact	Impact 90% Confidence Interval	
	(kWh)	(kWh)	(kWh)	(%)	Lower	Upper
Aug.	576	617	41	6.6%	20	61
Sep.	544	584	41	6.9%	12	69
Oct.	540	596	57	9.5%	24	90
Avg.	**553**	**599**	**46**	**7.7%**	**23**	**69**

EV-TOU (n< 300)

Month	HAN Consumption	Reference Consumption	Impact	Impact	Impact 90% Confidence Interval	
	(kWh)	(kWh)	(kWh)	(%)	Lower	Upper
Aug.	1,117	1,118	1	0%	-26	29
Sep.	1,051	1,066	15	1%	-17	46
Oct.	1,041	1,074	32	3%	-4	69
Avg.	**1,070**	**1,085**	**16**	**1%**	**-8**	**40**

Conclusions

- **The E-6 TOU customer group is the only group that shows statistically significant (90% confidence) reductions in monthly electricity consumption – 7.7%**
  - This impacts, combined with an absence of on-peak impact indicates that these customers are making behavioral changes during non-peak hours;
  - Consistent with the hypothesis that they have already reduced usage on-peak in response to the rate signal but that the IHD is leading to modified usage in other hours.
- **With respect to on-peak demand, only EV-TOU customers show statistically significant (90% confidence) average on-peak hourly load impacts – 5%.**
- **All participants of this pilot are from highly engaged PG&E customer segments so all findings must be viewed through that lens.**

References

PG&E HAN Phase 3 Report:
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PG&E HAN Phase 1 Report:
http://www.calmac.org/publications/HAN_Final_Report_FINAL.pdf

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http://www.powerauthority.on.ca/sites/default/files/conservation/2013-Evaluation-of-peaksaverPLUS-Nov-2014.pdf

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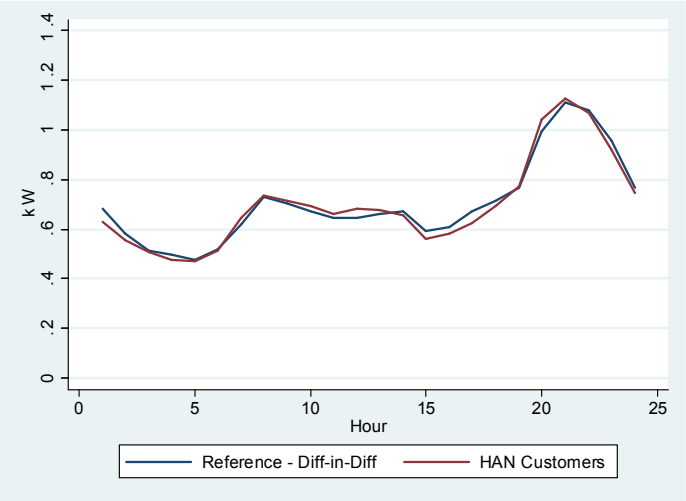
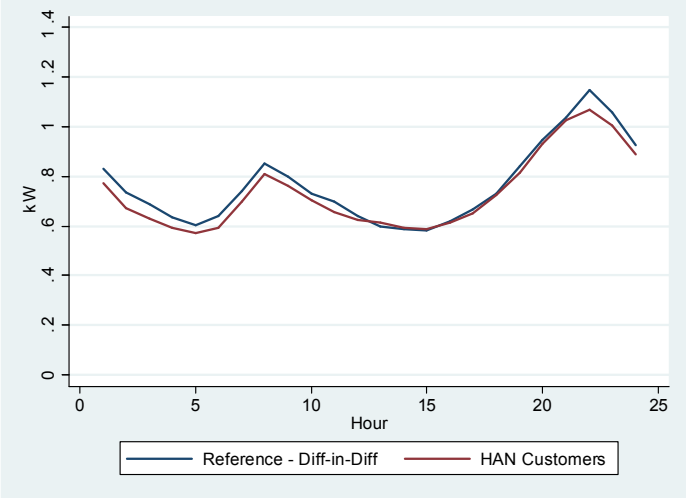
Hourly load shapes after IHDs are installed

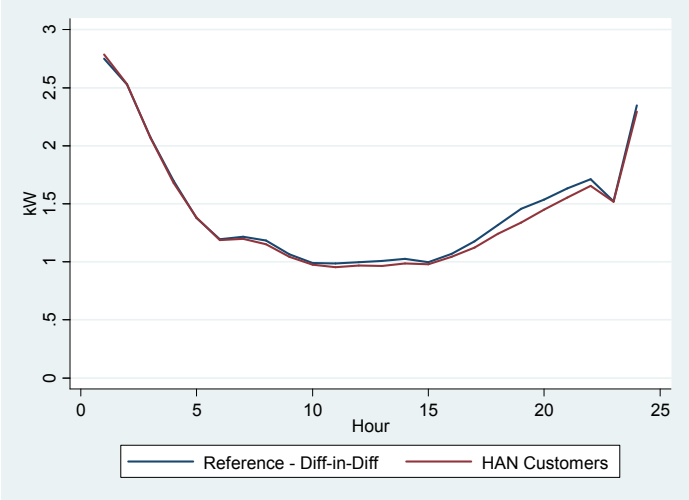
SmartRate (n > 1,000)



E-6 TOU (n< 300)

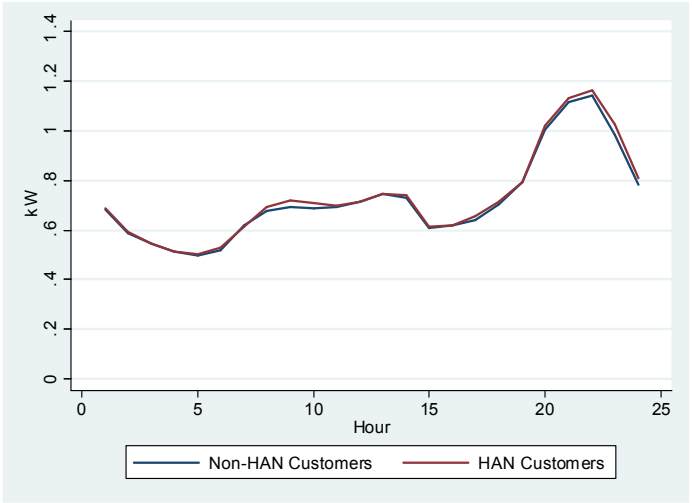


EV-TOU (n< 300)

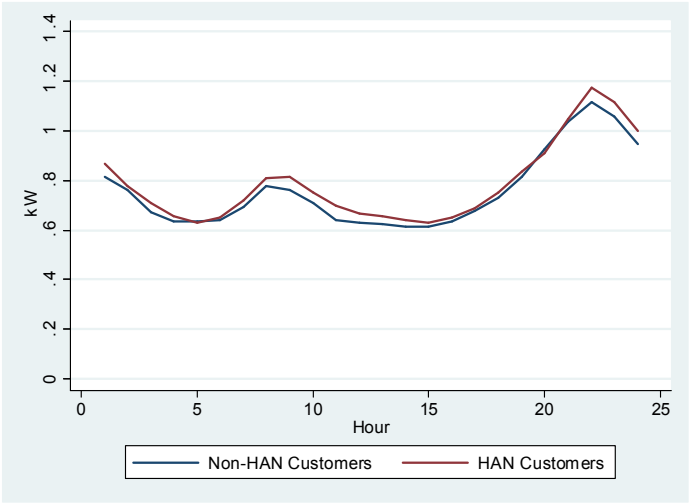


Considering the pretreatment period, the largest segment matched its control group best

Smart Rate (n > 1,000)



E-6 TOU (n< 300)



EV-TOU (n< 300)